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ORIGINAL ARTICLE

Academic Behaviors in Children with Convergence Insufficiency with and without Parent-Reported ADHD

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ABSTRACT

Purpose. To determine if children with symptomatic Convergence Insufficiency without the presence of parent-reported Attention Deficit Hyperactivity Disorder (ADHD) have higher scores on the academic behavior survey (ABS).

Methods. The ABS is a 6-item survey that evaluates parent concern about school performance and the parents' perceptions of the frequency of problem behaviors that their child may exhibit when reading or performing schoolwork (such as difficulty completing work, avoidance, and inattention). Each item is scored on an ordinal scale from 0 (Never) to 4 (Always) with a total score ranging from 0 to 24. The survey was administered to the parents of 212 children 9- to 17-year old (mean age 11.8 years.) with symptomatic convergence insufficiency before enrolling into the Convergence Insufficiency Treatment Trial and to 49 children with normal binocular vision (NBV) (mean age 12.5 years). The parents reported whether the child had ADHD, and this information was used to divide the symptomatic convergence insufficiency group into the convergence insufficiency with parent report of ADHD or convergence insufficiency with parent report of no ADHD groups.

Results. Sixteen percent of the convergence insufficiency group and 6% of the NBV group were classified as ADHD by parental report. An analysis of covariance showed that the total ABS score for the symptomatic convergence insufficiency with parent report of ADHD group (15.6) was significantly higher than the symptomatic convergence insufficiency with parent report of no ADHD group (11.7, $p = 0.001$) and the NBV group (8.7, $p < 0.0001$). Children with convergence insufficiency with parent report of no ADHD scored significantly higher on the ABS than the NBV group ($p = 0.036$).

Conclusions. Children with symptomatic convergence insufficiency with parent report of no ADHD scored higher on the ABS, when compared to children with NBV. Children with parent report of ADHD or related learning problems may benefit from comprehensive vision evaluation to assess for the presence of convergence insufficiency.

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Key Words: convergence insufficiency, attention deficit hyperactivity disorder, reading, symptoms, parent perception, school work performance

Convergence insufficiency is a common vision disorder characterized by exophoria greater at near than at distance, a receded near point of convergence, and reduced positive fusional vergence at near and has a prevalence of ~5%.[1–4] The adverse impact of convergence insufficiency occurs during near viewing where typical symptoms include double vision, blurred vision, eye strain, difficulty concentrating, and slow reading.[1, 5–9] Recently, child-reported symptoms associated with convergence insufficiency have been quantified using the convergence insufficiency symptom survey (CISS).[1, 6] The CISS allows a two-factor analysis of symptoms; first, whether the symptom is present, and second, how frequently the symptom occurs. The CISS has been shown to discriminate between children with convergence insufficiency and children with normal binocular vision (NBV) in clinical- and population-based settings.[1, 5, 6] In addition, children with three signs of convergence insufficiency have been able to provide reliable responses to the survey questions on the CISS.[6]

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In contrast to symptom reporting in children, the parent reports of their child's symptoms associated with convergence insufficiency have not been studied as thoroughly. Only one study has looked at agreement between parent and child reporting on the CISS and found that the parent and child tended to agree on whether the child was symptomatic or asymptomatic, although the total scores did not agree.[5] Investigating the parent reports of observable behaviors related to school work in children with symptomatic convergence insufficiency becomes especially important because of recent studies that have suggested a possible association between convergence insufficiency and a prevalent behavioral disorder, Attention Deficit Hyperactivity Disorder (ADHD).[10–12] Borsting et al.[10] argued that the symptoms frequently reported in convergence insufficiency such as loss of concentration when reading or reading slowly are similar to behaviors associated with ADHD (inattentive type), such as, failure to complete assignments and trouble concentrating in class.[13, 14] One criticism of the Borsting et al. study is that, in a study with a relatively small sample size, the convergence insufficiency group could have included children with ADHD, which may have in turn biased the parent toward reporting a higher frequency of behaviors. As a result, it would be of interest to determine if symptomatic convergence insufficiency children without reported ADHD had a significantly greater frequency of behaviors that may interfere with academic work.

Therefore, the purpose of this study was to determine if children with symptomatic convergence insufficiency without the presence of parent-reported ADHD have higher scores on our newly developed parent survey, the academic behavior survey (ABS) as reported by the parent. Thus, we compared parent self-reported responses on the ABS in children who have symptomatic convergence insufficiency with parent report of ADHD, symptomatic convergence insufficiency with parent report of no ADHD, and children with NBV and parent report of no ADHD.

PATIENTS AND METHODS

Survey Development

An expert clinician approach was used for developing the ABS, based on a previous study, which asked parents questions similar to those on the CISS along with items about short attention span and avoidance of near work.[5, 15] This study indicated that the parents of children with convergence insufficiency more frequently reported attention span problems and fails to finish things more than the NBV group.[5] Investigating academic-related behaviors was a secondary outcome of the Convergence Insufficiency Treatment Trial (CITT), which evaluated different treatment modes for remediating convergence insufficiency. Both the Data Safety and Monitoring Committee and the Executive Committee decided that a brief survey that asked a few questions was the most appropriate method to probe this issue in children with convergence insufficiency, instead of using lengthy standardized surveys of children's behavior. We developed questions that addressed behaviors that a parent could easily observe such as avoiding near work and problems with completing school work. In addition, we included one question regarding the parent's level of concern about school performance. Previous research has found that the parent and child agreement is better when items that are easily observable (such as walking up and down stairs) are used, as opposed to, reporting on somatic issues (such as amount of pain), which are more subjective.[16–18] A list of potential questions was generated and field tested by the CITT Executive Committee along with select members of the CITT investigators research team. On the basis of this feedback, the final six questions were developed with each item scored on an ordinal scale from 0 (Never) to 4 (Always) as used in the CISS, with a range of possible scores from 0 to 24[6, 19] (Fig. 1).

Subject Selection

The study was supported through a cooperative agreement with the National Eye Institute of the National Institutes of Health (NCT00338611) and conducted by the CITT Group at nine clinical sites (see Acknowledgments). The respective institutional review boards approved the protocol and Health Insurance Portability and Accountability Act-compliant informed consent forms. The parent or legal guardian of each study subject gave written informed consent and written assent was obtained from each child. Study oversight was provided by an independent data and safety monitoring committee appointed by National Eye Institute.

		Never	Infrequently	Sometimes	Fairly often	Always
1.	How often does your child have difficulty completing assignments at school?					
2.	How often does your child have difficulty completing homework?					
3.	How often does your child avoid or say he/she does not want to do tasks that require reading or close work?					
4.	How often does your child fail to give attention to details or make careless mistakes in schoolwork or homework?					
5.	How often does your child appear inattentive or easily distracted during reading or close work?					
6.	How often do you worry about your child's school performance?					

FIGURE 1.
The Academic Behavior Survey.

Children aged from 9 to 17 inclusive with symptomatic convergence insufficiency were recruited to meet the inclusion and exclusion criteria for the CITT at participating centers.[20] The NBV subjects were recruited in a similar manner at six of the nine CITT study sites as part of an ancillary study (appendix). The NBV children had the same exclusion criteria as the CITT, and the inclusion criteria are listed in Table 1. To assess eligibility, both the convergence insufficiency and NBV subjects received the same testing to evaluate binocular vision and accommodative ability.

Procedures

The ABS was completed by the parent or guardian present at the eligibility examination of children with symptomatic convergence insufficiency or NBV. The parent was given the ABS as the last document in a series of documents that recorded demographic information, medication information, and health history. The following instructions were included on the ABS form: Please rate each item according to your child's behavior during the last school month. If your child was not in school last month, think about during the last month he/she was in school. For each item, ask yourself "How much of a problem has this been in the last month?" and check the best answer for each one. Please respond to all six items. The parent was not allowed to consult with the child during the completion of the survey. Before filling out the ABS, parents or guardians were asked the following question to identify the presence or absence of ADHD as part of the demographic information: "Has a doctor ever told you that your child has Attention Deficient/Hyperactivity Disorder (ADHD) or Attention Deficient Disorder (ADD)?"

TABLE 1.
Inclusion criteria for NBV subjects

Age 9 to <18 years
Sex: either
Ethnicity: any
Best-corrected visual acuity of 20/25 or better in both eyes at distance and near
Appropriate refractive correction worn for at least 2 weeks
Heterophoria at near between 2Δ esophoria and 8Δ exophoria
Negative fusional vergence at near (greater than 7Δ BI-break/5Δ BI-recovery)
Positive fusional vergence at near (greater than 10Δ BO-break/ 7Δ BO-recovery)
NPC closer than 6.0 cm break
Monocular amplitude of accommodation (greater than 15–0.25 × age)
Appreciation of random dot stereopsis using a 500 sec of arc target
Had cycloplegia refraction within past 2 months
Informed consent and willingness to participate in the study

Data Analysis

Survey

The ABS is scored on an ordinal scale from 0 (Never) to 4 (Always), with a range of possible scores from 0 to 24 (Fig. 1). To determine if it was appropriate to use the simple sum of the six items on the ABS as a measure of academic behavior, two separate analyses were performed. In the first analysis, the internal consistency of the responses on the ABS was assessed using the Cronbach Alpha. This analysis suggested excellent consistency with a value of 0.92 for the six-item survey. The removal of any individual item did not improve the internal consistency of the survey. Next, a principal components analysis was used to examine the effect of using a different weighting scheme when determining the ABS score. This analysis offers a method of summarizing the data by developing a linear combination of the six items of the ABS, which maximizes the variability explained (i.e., the first principal component). For these data, the first principal component explained 71% of the variability in responses and was, in fact, the only factor with an eigenvalue >1. To test the robustness of our findings, all comparisons of the ABS score between groups were repeated using the weighting scheme of the first principal component. The findings were identical to those reported herein.

Comparison of the mean score on the ABS between the three patient groups was performed using an analysis of covariance (ANCOVA). Given the non-random nature of the data, it was important to identify factors that may serve as confounders to the true relationship between study group and ABS. By definition, a factor is classified as a potential confounder if it is related to both ABS score and study group. As a first step in identifying these confounders, analysis of variance and χ^2 tests were used to compare the three patient groups with respect to demographic and clinical variables. Analysis of variance and Pearson correlations were used to assess the relationship between ABS score and each demographic and clinical variable. Variables found to be significantly different across study groups and related to ABS score were included in initial ANCOVA models containing study group one at a time. If these variables remained significant in the ANCOVA model ($p < 0.05$), they were retained for inclusion in the final ANCOVA model assessing the relationship between study group and ABS score.

The distribution of responses for each of the six items of the ABS was compared between groups using a Kruskal–Wallis test. When assessing the results of the Kruskal-Wallis test, a Bonferroni adjustment ($\alpha = 0.05/6 = 0.0083$) was made to adjust for the multiple statistical tests performed. Posthoc pair-wise comparisons were performed using the Wilcoxon rank sum test.

TABLE 2.
Number of subjects in each group

CI with no parent report of ADHD	CI with parent report of ADHD	NBV with no parent report of ADHD	NBV with parent report of ADHD (sample excluded from data analysis)
N = 176	N = 34	N = 46	N = 3

RESULTS

The survey was administered to the parents or guardians of 221 children with symptomatic convergence insufficiency (mean age 11.8 years) before enrollment into the CITT and to the parents of 49 children with NBV (mean age 12.5 years) as part of an ancillary study. The ADHD status was not recorded for nine children with convergence insufficiency, and they were excluded from the subsequent analysis. In the convergence insufficiency group, parents or guardians of 34 (16%) children responded positively to the question about the diagnosis of ADHD by a medical professional. Of the convergence insufficiency children with parent report of ADHD, 19 (56%) were on psychotropic medications, whereas only two children in the parent report of no ADHD group were taking psychotropic medications. In the NBV group, 3 (6%) responded positively to the presence of ADHD. A χ^2 test showed only a trend in the percentage of parent-report ADHD in the convergence insufficiency compared with the NBV groups (16 vs. 6%; $\chi^2 = 3.22$, $p = 0.073$). The two convergence insufficiency children with parent report of no ADHD but psychotropic medication use and the three NBV children with ADHD were excluded from all further analyses (Table 2 provides number of subjects in each group).

TABLE 3.
Summary statistics for clinical and demographic measures at the enrollment visit, by study group

Characteristic	CI group		NBV group (n = 46)	p
	w/o ADHD (n = 176)	w/ADHD (n = 34)		
Mean (std) age in years	11.8 (2.4)	12.1 (2.2)	12.5 (2.4)	0.15
% Female	59.1	50.0	60.9	0.57
Mean (std) near point of convergence (cm)				
Break	14.4 (7.3)	13.4 (8.9)	3.5 (1.2)	<0.0001
Recovery	18.1 (7.7)	17.5 (10.5)	5.2 (1.6)	<0.0001
Mean (std) positive fusional vergence (Δ)				
Blur/break	10.9 (4.0)	11.7 (3.4)	24.0 (10.2)	<0.0001
Recovery	8.9 (4.5)	9.3 (4.6)	22.1 (7.7)	<0.0001
Mean (std) phoria (Δ)				
At near	9.1 exo (4.3)	8.8 exo (4.0)	2.1 exo (2.3)	<0.0001
At distance	1.9 exo (2.7)	1.3 exo (2.2)	0.6 exo (1.3)	0.005
% Intermittent exotropia				
At near	9.7	2.9	0.0	0.045
At distance	2.3	0.0	0.0	0.40
% Failed sheard criterion	82.4	76.5	2.2	<0.0001
CISS Score	29.5 (8.7)	34.1 (8.6)	10.4 (8.1)	<0.0001
Race (%)				
American Indian/Alaskan Native	4.6	6.1	0.0	0.057
Asian/Pacific Islander	2.3	0.0	2.2	
Black or African American	30.9	24.2	45.7	
White	53.1	63.6	32.6	
Other	9.1	6.1	19.6	
% Hispanic or Latino	34.1	26.5	13.0	0.019
Mean (std) accommodative amplitude (D)	9.8 (3.8)	10.2 (4.2)	16.2 (4.1)	<0.0001
% With accommodative insufficiency	56.8	52.9	0.0	<0.0001
Mean (std) accommodative facility (cycles)	6.5 (4.3)	5.6 (4.9)	8.9 (5.8)	0.003
% 20/20 or better visual acuity at near	79.6	82.4	100.0	0.004
% 20/20 or better visual acuity at distance	88.6	91.2	89.1	0.91
Mean (std) spherical equivalent—OD (D)	−0.06 (1.4)	0.09 (1.7)	−0.75 (2.0)	0.016
Refractive error category—OD				
% Myopic (nearsighted)	22.2	17.7	30.4	0.013
% Hyperopic (farsighted)	7.4	20.6	0.0	
% Emmetropic (normal)	70.4	61.8	69.6	
% Children wearing correction	33.0	35.3	37.0	0.87

Descriptive statistics for demographic and clinical measures by study group are listed in Table 3. Significantly fewer children in the NBV group reported Hispanic or Latino ethnicity compared with either of the convergence insufficiency groups ($p = 0.019$). This is most likely due to CITT site participation in the ancillary study because some study sites, which had enrolled a significant number of Hispanic or Latino children in the CITT, chose not to participate in the NBV ancillary study. There was a significant difference in the level of refractive error observed across the three-study groups ($p = 0.016$). Children enrolled in the NBV study were slightly more myopic (mean = −0.75 D) when compared with the children with symptomatic convergence insufficiency with parent report of no ADHD (mean = −0.06 D, $p = 0.020$). There was also a marginally significant difference between the NBV study group and the symptomatic convergence insufficiency with parent report of ADHD group (mean = +0.09 D, $p = 0.045$). No difference was observed between the two convergence insufficiency groups ($p = 0.87$).

Significant differences between the convergence insufficiency and NBV groups with respect to clinical signs of convergence insufficiency (such as near point of convergence, positive fusional vergence, and phoria) and the CISS were a by-product of the inclusion/exclusion criteria used to identify the convergence insufficiency and NBV subjects. In addition, there was a significantly higher CISS score in convergence insufficiency children with parent report of ADHD compared to their counterparts with parent report of no ADHD ($p = 0.012$).

Refractive error and CISS score were the only variables from Table 3 included in the final ANCOVA model comparing the mean ABS score between the three patient groups. In this model, hyperopic increases in refractive error were associated with increases in the ABS score ($\beta = 0.47$, $p = 0.040$). Similarly, higher level of symptoms were associated with higher ABS scores ($\beta = 0.16$, $p < 0.0001$). The adjusted mean ABS score among children with NBV was 8.7 points [95% confidence interval (CI) = 6.6 to 10.8], which was significantly lower than the ABS score for either the symptomatic convergence insufficiency with parent report of ADHD or symptomatic convergence insufficiency with parent report of no ADHD groups ($p < 0.0001$ and $p = 0.036$, respectively). Among children who had convergence insufficiency with parent report of no ADHD, the mean ABS was 11.7 points (95% CI = 10.9 to 12.6) and the mean for the symptomatic convergence insufficiency with parent report of ADHD was 15.6 points (95% CI = 13.6 to 17.5). There was also a significant difference in the scores observed in the two convergence insufficiency groups ($p = 0.001$).

As shown on Figs. 2 to 7, the distribution of responses on each of the six-survey items differed between the three patient groups

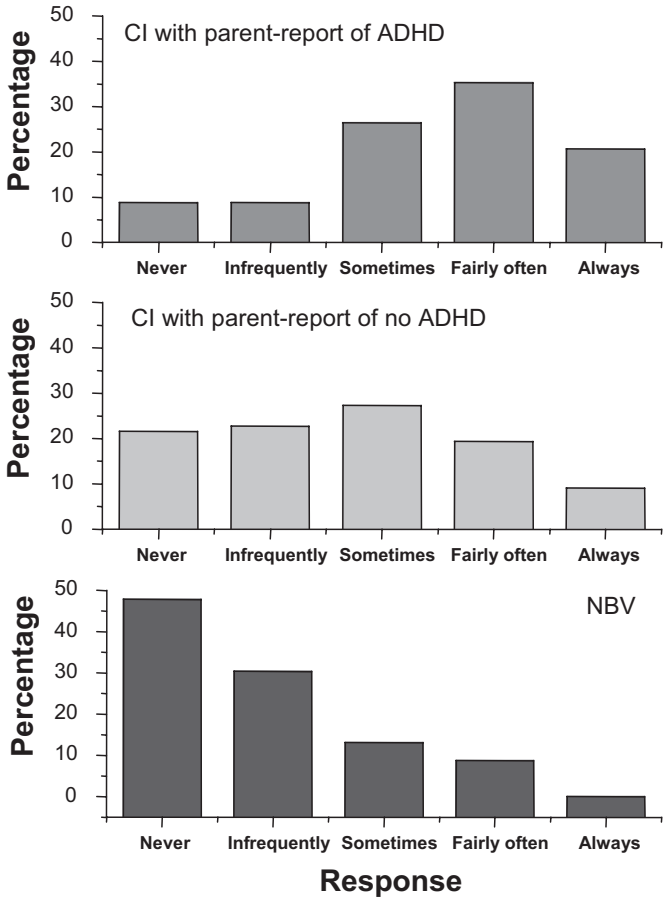

FIGURE 2.

The percentage of parents responding to each category on the ABS for the convergence insufficiency children with parent-report ADHD, convergence insufficiency with parent report of no ADHD, and NBV groups for question 1: How often does your child have difficulty completing assignments at school?

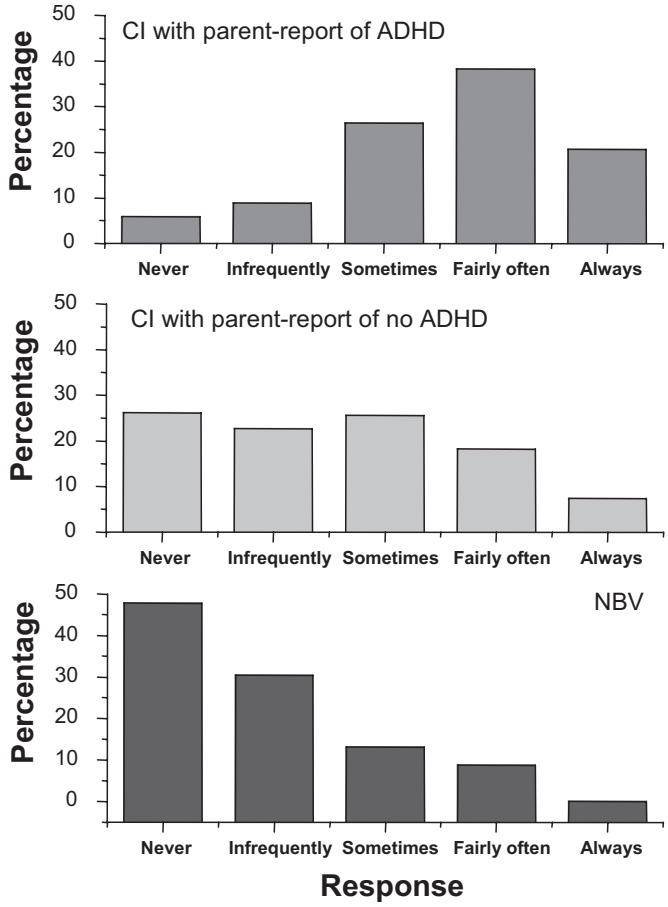

FIGURE 3.

The percentage of parents responding to each category on the ABS for the convergence insufficiency children with parent-report ADHD, convergence insufficiency with parent report of no ADHD, and NBV groups for question 2: How often does your child have difficulty completing homework?

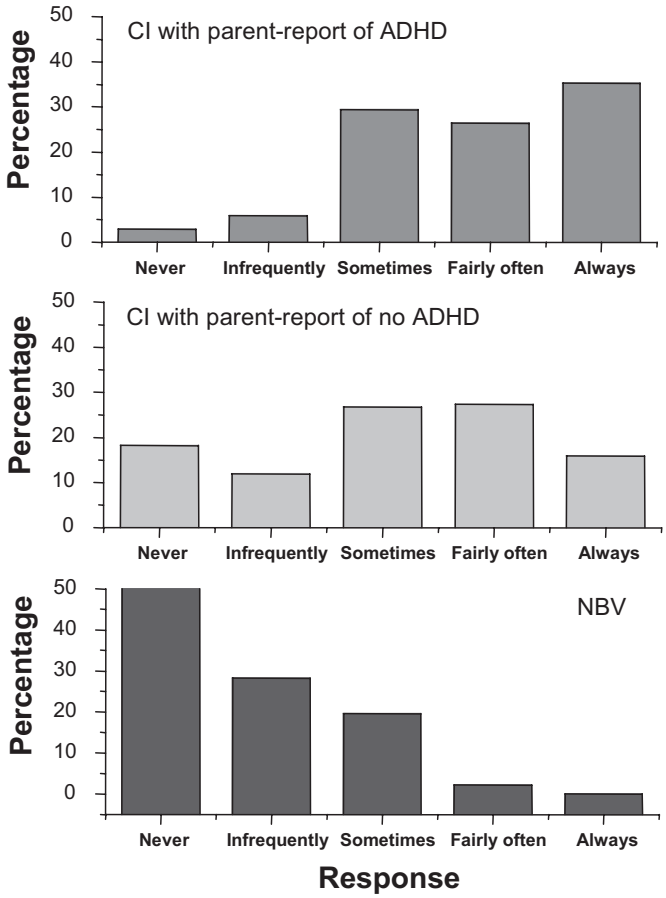

FIGURE 4.
The percentage of parents responding to each category on the ABS for the convergence insufficiency children with parent-report ADHD, convergence insufficiency with parent report of no ADHD, and NBV groups for question 3: How often does your child avoid or say he/she does not want to do tasks that require reading or close work?

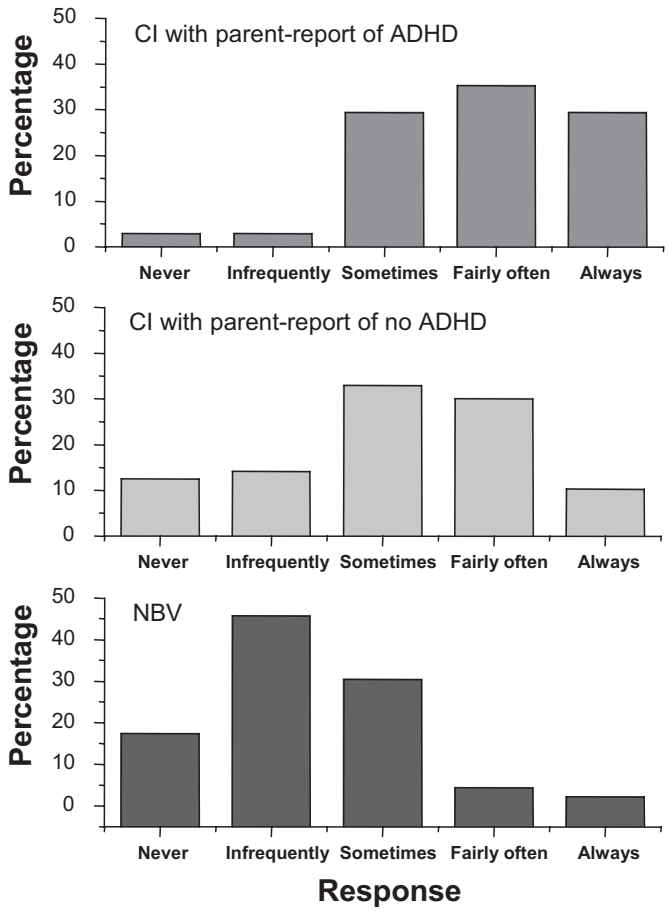

FIGURE 5.
The percentage of parents responding to each category on the ABS for the convergence insufficiency children with parent-report ADHD, convergence insufficiency with parent report of no ADHD, and NBV groups for question 4: How often does your child fail to give attention to details or make careless mistakes in schoolwork or homework?

($p < 0.0001$ for each comparison). After controlling for multiple comparisons, the scores for five of the six items of the ABS were higher in the symptomatic convergence insufficiency with parent report of ADHD group, when compared to the symptomatic convergence insufficiency with parent report of no ADHD group. After controlling for multiple comparisons, only the parent's worry about their child's performance was not significantly higher in the symptomatic convergence insufficiency with parent report of ADHD group ($p = 0.019$). When comparing both convergence insufficiency groups to the NBV group significant differences were seen for children with parent report of no ADHD, as well as those children with parent report of ADHD ($p < 0.001$ for all comparisons).

DISCUSSION

Our results indicate that the children with symptomatic convergence insufficiency with parent report of ADHD scored higher on the ABS, when compared to children who had symptomatic convergence insufficiency with parent report of no ADHD, and that both convergence insufficiency groups scored significantly higher on the ABS survey, when compared to children with NBV. These results are consistent with previous studies that have assessed symptoms in children with the CISS.[1, 6] Thus, both children with symptomatic convergence insufficiency and their parents report a significantly higher number of academic performance symptoms, when compared to children with NBV.

The results of this study indicate that the presence of convergence insufficiency was associated with higher scores on the ABS even after accounting for child's initial symptom level on the CISS in a large of sample of symptomatic convergence insufficiency children. This addresses one of the criticisms of our previous studies that reported similar findings with much smaller sample sizes. The convergence insufficiency with parent report of no ADHD group scored three points higher on the ABS than the NBV group. The question arises as to the clinical significance of the statistically significant result. Although the ABS is a newer clinical instrument, we can still investigate the effect size of the difference between the groups. A three-point change translates into an effect size of 0.5. According to Cohen,[21] this effect would be classified as medium (0.5).

One limitation of our study is that we did not include a group of NBV children with parent report of ADHD. It would be of interest to determine if children with NBV with parent report of ADHD would score higher on the ABS, when compared with the other three groups. A study with all four groups could provide further information about the relative contributions of conver-

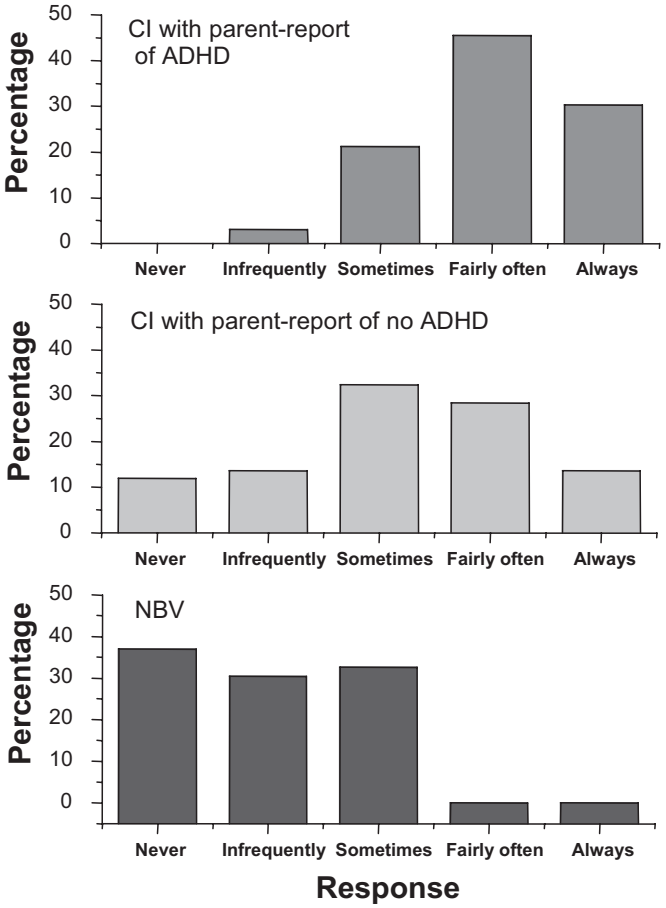

FIGURE 6.

The percentage of parents responding to each category on the ABS for the convergence insufficiency children with parent-report ADHD, convergence insufficiency with parent report of no ADHD, and NBV groups for question 5: How often does your child appear inattentive or easily distracted during reading or close work?

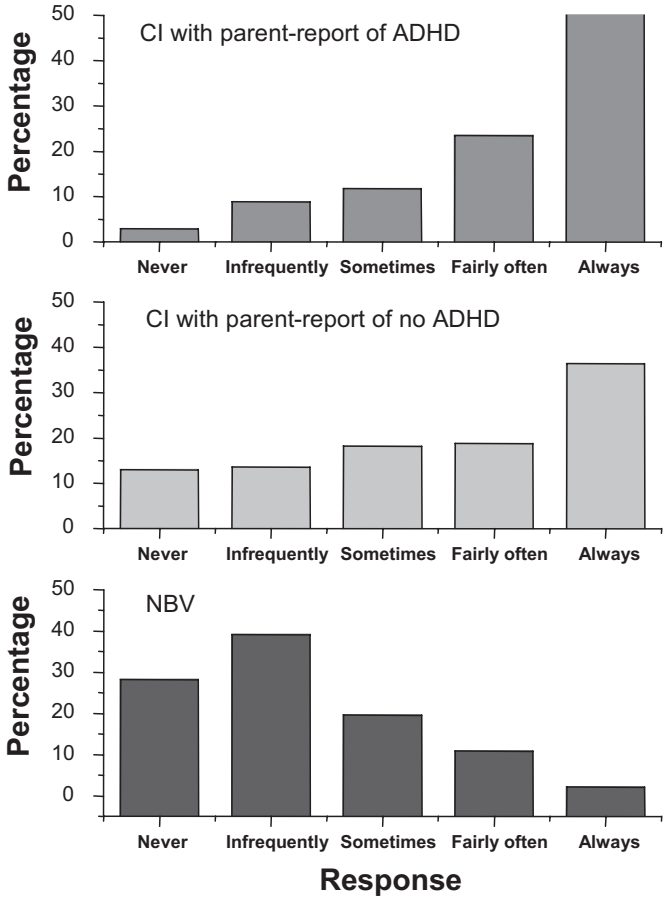

FIGURE 7.

The percentage of parents responding to each category on the ABS for the convergence insufficiency children with parent-report ADHD, convergence insufficiency with parent report of no ADHD, and NBV groups for question 6: How often do you worry about your child's school performance?

gence insufficiency and ADHD to scores on the ABS as well as the CISS. Another limitation of this study was that our sample represented a preselected group of symptomatic convergence insufficiency children with three signs of convergence insufficiency.[20] Our results may not apply to children who have normal scores (≤16) on the CISS or who have milder cases of convergence insufficiency that do not exhibit all three clinical signs.

Given that symptomatic convergence insufficiency children have symptoms and behaviors similar to children with ADHD, it would be of interest to determine if the prevalence of convergence insufficiency is higher in an ADHD population. Some preliminary studies have suggested this possibility. Granet et al.[11] found a higher prevalence of ADHD in children diagnosed with convergence insufficiency when conducting a retrospective review of charts. Gronlund et al.[11, 12] found one sign of convergence insufficiency (abnormal near point of convergence) in 24% of the ADHD group but only 6% of the reference group. Because of the small number of NBV children with ADHD in our sample it is difficult for our study to answer this question but this issue should be investigated in an ADHD sample.

There are several sources of bias that potentially exist in our study. The higher scores in the symptomatic convergence insufficiency with parent report of ADHD group could be attributed to parent bias when filling out the ABS. Parents, who self-reported ADHD, may have interpreted the items on the ABS as similar to ADHD and in turn ranked the child higher on this survey. This potential source of bias was mitigated, in part, by titling the survey as the ABS. Examiner bias was kept to a minimum by masking the examiner to the parent's response to the question about the presence of ADHD and having the parent fill out the survey by themselves, without verbal instructions from the examiner. The parents also reported an increase frequency of worry in both the convergence insufficiency with no parent report of ADHD and in the convergence insufficiency with parent report of ADHD, when compared to the NBV group. It would be likely for the parent to report an increase frequency of worry due to the bias that parents pursue eye care because he/she feels that the child has a significant problem. However, both the convergence insufficiency and NBV group were recruited in a similar manner from clinic populations at each site. Children with higher symptom level on the CISS could have biased the parent to report a higher frequency of behaviors on the ABS. This potential bias was controlled for by using the CISS as a covariate in our analysis.

Another source of bias was that, we relied on parental report for the presence of ADHD, and we did not confirm that a diagnosis

had been made by a qualified professional. This could lead to two sources of bias. First, although, we specifically asked if a doctor had told the parent that the child had ADHD, it is possible that some parents reported ADHD that had not been diagnosed by a qualified professional. The National Survey of Children's Health conducted in 2003 used a telephone survey and asked similar questions about ADHD to our study.[22] A subsequent analysis of the data showed that the parental report of ADHD was 9.7% among children ages 9 to 17 and medication usage was 64% in the 9- to 12-age group and was 47% in the 13- to 17-age group.[23] The reported prevalence of ADHD in our convergence insufficiency group of 15.4% and the parental report of medication usage of 56% was similar to the data from the National Survey of Children's Health for the 9- to 17-age range. Our distribution of parent reported ADHD is quite similar to that reported in a large population-based study. Second, our convergence insufficiency with parent report of no ADHD group could have included children with undiagnosed ADHD. Without a medical evaluation for ADHD for all the subjects, it is not possible to know definitively that each group was composed of only one classification or the other. However, given the large number of convergence insufficiency children in this group it is unlikely that the presence of a few subjects with undiagnosed ADHD would have altered the results.

In conclusion, the presence of convergence insufficiency contributes to the parents' reports of difficulty with their child's ability to complete schoolwork efficiently. In addition, parents of children with convergence insufficiency reportedly "worry" more about their children's school performance than parents of children with NBV. Children with parent-reported ADHD or related learning problems may benefit from comprehensive vision evaluation to assess for the presence of convergence insufficiency beyond a typical vision screening, which targets the detection of strabismus, amblyopia, and significant refractive error.

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The Convergence Insufficiency Treatment Trial Investigator Group
Clinical Sites

Sites are listed in order of the number of patients enrolled in the study with the number of NBV patients enrolled listed in parentheses preceded by the site name and location. Personnel are listed as (PI) for principal investigator, (SC) for coordinator, (E) for examiner, and (VT) for therapist.

Study Center: SUNY College of Optometry (8 NBV, 28 CI)
Jeffrey Cooper, OD (PI); Audra Steiner, OD (E, Co-PI); Marta Brunelli (VT); Stacy Friedman, OD (VT); Steven Ritter, OD (E); Lily Zhu, OD (E); Lyndon Wong, OD (E); Ida Chung, OD (E); Kaity Colon (SC).

Study Center: Bascom Palmer Eye Institute (35 CI)
Susanna Tamkins, OD (PI); Hilda Capo, MD (E); Mark Dunbar, OD (E); Craig McKeown, MD (CO-PI); Arlanna Moshfeghi, MD (E); Kathryn Nelson, OD (E); Vicky Fischer, OD (VT); Adam Perlman, OD (VT); Ronda Singh, OD (VT); Eva Olivares (SC); Ana Rosa (SC); Nidia Rosado (SC); Elias Silverman (SC).

Study Center: NOVA Southeastern University (8 NBV, 27 CI)
Rachel Coulter, OD (PI); Deborah Amster, OD (E); Gregory Fecho, OD (E); Tanya Mahaphon, OD (E); Jacqueline Rodena, OD (E); Mary Bartuccio, OD (VT); Yin Tea, OD (VT); Annette Bade, OD (SC).

Study Center: UAB School of Optometry (7 NBV, 28 CI)
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Study Center: Pennsylvania College of Optometry (9 NBV, 25 CI)
Michael Gallaway, OD (PI); Brandy Scombordi, OD (E); Mark Boas, OD (VT); Tomohiko Yamada, OD (VT); Ryan Langan (SC), Ruth Shoge, OD (E); Lily Zhu, OD (E).

Study Center: The Ohio State University College of Optometry (8 NBV, 24 CI)
Marjean Taylor Kulp, OD, MS (PI); Michelle Buckland, OD (E); Michael Earley, OD, PhD (E); Gina Gabriel, OD, MS (E); Aaron Zimmerman, OD (E); Kathleen Reuter, OD (VT); Andrew Toole, OD, PhD (VT); Molly Biddle, MEd (SC); Nancy Stevens, MS, RD, LD (SC).

Study Center: Southern California College of Optometry (9 NBV, 23 CI)
Susan Cotter, OD, MS (PI); Eric Borsting, OD, MS (E); Michael Rouse, OD, MSEd, (E); Carmen Barnhardt, OD, MS (VT); Raymond Chu, OD (VT); Susan Parker (SC); Rebecca Bridgeford (SC); Jamie Morris (SC); Javier Villalobos (SC).

Study Center: University of CA San Diego: Ratner Children's Eye Center (17 CI)
David Granet, MD (PI); Lara Hustana, OD (E); Shira Robbins, MD (E); Erica Castro (VT); Cintia Gomi, MD (SC).

Study Center: Mayo Clinic (14 CI)
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REFERENCES

1. Borsting E, Rouse MW, Deland PN, Hovett S, Kimura D, Park M, Stephens B. Association of symptoms and convergence and accommodative insufficiency in school-age children. Optometry 2003;74: 25–34.
2. Rouse MW, Borsting E, Hyman L, Hussein M, Cotter SA, Flynn M, Scheiman M, Gallaway M, De Land PN. Frequency of convergence insufficiency among fifth and sixth graders. The Convergence Insufficiency and Reading Study (CIRS) group. Optom Vis Sci 1999;76: 643–9.
3. Letourneau JE, Ducic S. Prevalence of convergence insufficiency among elementary school children. Can J Optom 1988;50:194–7.
4. Letourneau JE, Lapierre N, Lamont A. The relationship between convergence insufficiency and school achievement. Am J Optom Physiol Opt 1979;56:18–22.
5. Borsting E, Rouse MW, De Land PN. Prospective comparison of convergence insufficiency and normal binocular children on CIRS

symptom surveys. The Convergence Insufficiency and Reading Study (CIRS) Group. Optom Vis Sci 1999;76:221–8.
6. Borsting EJ, Rouse MW, Mitchell GL, Scheiman M, Cotter SA, Cooper J, Kulp MT, London R. Validity and reliability of the revised convergence insufficiency symptom survey in children aged 9 to 18 years. Optom Vis Sci 2003;80:832–8.
7. Daum KM. Convergence insufficiency. Am J Optom Physiol Opt 1984;61:16–22.
8. Pickwell LD, Hampshire R. The significance of inadequate convergence. Ophthalmic Physiol Opt 1981;1:13–8.
9. Cooper J, Duckman R. Convergence insufficiency: incidence, diagnosis, and treatment. J Am Optom Assoc 1978;49:673–80.
10. Borsting E, Rouse M, Chu R. Measuring ADHD behaviors in children with symptomatic accommodative dysfunction or convergence insufficiency: a preliminary study. Optometry 2005;76: 588–92.
11. Granet DB, Gomi CF, Ventura R, Miller-Scholte A. The relationship between convergence insufficiency and ADHD. Strabismus 2005;13: 163–8.
12. Gronlund MA, Aring E, Landgren M, Hellstrom A. Visual function and ocular features in children and adolescents with attention deficit hyperactivity disorder, with and without treatment with stimulants. Eye 2007;21:494–502.
13. American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders, 4th ed. Washington, DC: American Psychiatric Association; 1994.
14. Connors C. Manual for Connors' Rating Scales. Toronto: Multi-Health Systems; 1997.
15. Streiner DL, Norman GR. Health Measurement Scales: A Practical Guide to Their Development and Use, 2nd ed. Oxford: Oxford University Press; 1995.
16. Doherty E, Yanni G, Conroy RM, Bresnihan B. A comparison of child and parent ratings of disability and pain in juvenile chronic arthritis. J Rheumatol 1993;20:1563–6.
17. Osman L, Silverman M. Measuring quality of life for young children with asthma and their families. Eur Respir J Suppl 1996;21:35s–41s.
18. Edelbrock C, Costello AJ, Dulcan MK, Conover NC, Kala R. Parent-child agreement on child psychiatric symptoms assessed via structured interview. J Child Psychol Psychiatry 1986;27:181–90.
19. Mosteller F, Youtz C. Quantifying probabilistic expressions. Stat Sci 1990;5:2–34.
20. Convergence Insufficiency Treatment Trial (CITT) Study Group. The convergence insufficiency treatment trial: design, methods, and baseline data. Ophthalmic Epidemiol 2008;15:24–36.
21. Cohen J. Statistical Power Analysis for the Behavioral Sciences, 2nd ed. Hillsdale, NJ: L. Earlbaum Associates; 1988.
22. Blumberg SJ, Olson L, Frankel M, Osborn L, Srinath K, Giambo P. Design and Operation of the National Survey of Children's Health, 2003. Hyattsville, MD: Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics; 2005.
23. Centers for Disease Control and Prevention. Mental health in the United States. Prevalence of diagnosis and medication treatment for attention-deficit/hyperactivity disorder—United States, 2003. MMWR Morb Mortal Wkly Rep 2005;54:842–7.

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